

APPENDIX A

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

Product Name: Marine Oil

Product Use: Dietary supplement

WHMIS Class: Not Controlled

TDG Classification: Not Regulated

Manufacturer/Supplier: Neptune Technologies & Bioresources
Address: 500 boul Saint-Martin Ouest
 Bureau 550
Telephone: 450 - 972-6291519

SECTION II - HAZARDOUS INGREDIENTS

Ingredients	CAS#	Wt%	OSHA-PEL	ACGIH-TLV	LC 50	LD 50
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None by WHMIS/OSHA criteria.

SECTION III - PHYSICAL DATA

Boiling Point (°C): Not available	Specific Gravity (w20 = 1): Not available
Vapour Pressure (mm Hg): Not available	% Volatile (Wt %): Not available
Vapour Density (Air = 1): Not available	Evaporation Rate (Ether = 1): Not available
Solubility in Water: Insoluble	pH (100%): Not available
Physical State: Liquid	Viscosity: Viscous
Appearance: Brown	Odour Threshold (ppm): Not available

SECTION IV - FIRE AND EXPLOSION DATA

Flammability: Not flammable by WHMIS/OSHA criteria.
Flash Point (°C, TCC): None **LEL:** Not applicable **UEL:** Not applicable
Hazardous Combustion Products: May include and are not limited to oxides of carbon
Autoignition Temperature (°C): Not applicable
Means of Extinction: Treat for surrounding material.
Special Fire Hazards: Firefighters should wear self-contained breathing apparatus.

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SECTION V - REACTIVITY DATA

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Conditions for Chemical Instability: Stable.

Incompatible Materials: None known.

Reactivity, and Under What Conditions: Not available.

Hazardous Decomposition Products: May include and are not limited to oxides of carbon when heated to
Decomposition

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SECTION VI - TOXICOLOGICAL PROPERTIES

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Route of Entry: Eye, Skin contact, Inhalation, Ingestion.

EFFECTS OF ACUTE EXPOSURE:

Eye: May cause irritation upon direct contact.

Skin: May cause irritation upon direct contact.

Inhalation: May cause respiratory tract irritation.

Ingestion: May cause stomach distress, nausea or vomiting if ingested in large quantities.

EFFECTS OF CHRONIC EXPOSURE:

Skin: Prolonged or repeated exposure can cause drying, defatting and dermatitis.

Irritancy: Non-hazardous by WHMIS/OSHA criteria.

Respiratory Tract Sensitization: No data available.

Carcinogenicity: Non-hazardous by WHMIS/OSHA criteria.

Teratogenicity, Mutagenicity, Reproductive Effects: No data available.

Synergistic Materials: Not available.

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SECTION VII- PREVENTATIVE MEASURES

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Gloves: No requirements beyond standard industrial hygiene practices.

Eye Protection: No requirements beyond standard industrial hygiene practices.

Respiratory Protection: Not normally required if good ventilation is maintained.

Other Protective Equipment: As required by employer code.

Engineering Controls: General ventilation normally adequate.

Leak and Spill Procedure: Before attempting clean up, refer to hazard data given above. Small spills may be absorbed

with non-reactive absorbent and placed in suitable, covered, labelled containers. Prevent large spills from entering sewers or

waterways. Contact emergency services and supplier for advice.

Waste Disposal: Review federal, state/provincial, and local government requirements prior to disposal.

Storage and Handling Requirements: Keep out of reach of children. Store in a closed container away from incompatible materials.

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SECTION VIII - FIRST AID

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Eye: Flush with cool water. Remove contact lenses, if applicable, and continue flushing. Obtain medical attention if irritation persists.

Skin: Flush with cool water. Wash with soap and water. Obtain medical attention if irritation persists.

Inhalation: If symptoms develop move victim to fresh air. If symptoms persist, obtain medical attention.

Ingestion: Do not induce vomiting. Rinse mouth with water then drink one or two glasses of water. Obtain medical attention.

Never give anything by mouth if victim is unconscious, or is convulsing.

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SECTION IX - PREPARATION INFORMATION

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Date: 2002/01/24
Telephone: 1 - 519- 438-9374

MSDS Prepared by: KKK SYNERGIZE INC.

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Disclaimer

Information for this material safety data sheet was obtained from sources considered technically accurate and reliable. While every effort has been made to ensure full disclosure of product hazards, in some cases data is not available and is so stated. Since conditions of actual product use are beyond control of the supplier, it is assumed that users of this material have been fully trained according to the mandatory requirements of WHMIS. No warranty, expressed or implied, is made and supplier will not be liable for any losses, injuries or consequential damages which may result from the use of or reliance on any information contained in this form. If user requires independent information on ingredients in this or any other material, we recommend contact with the Canadian Centre for Occupational Health and Safety (CCOHS) in Hamilton, Ontario (1-905-572-4400) or CSST in Montreal, Quebec (514-873-3990).

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

Product Name: Krill Protein

Product Use: Dietary supplement

WHMIS Class: Not Controlled

TDG Classification: Not Regulated

Manufacturer/Supplier: Neptune Technologies & Bioresources
Address: 500 boul Saint-Martin Ouest
Bureau 550
Laval, Quebec, H7M 3Y2
Telephone: 450 - 972-6291

SECTION II - HAZARDOUS INGREDIENTS

<u>Ingredients</u>	<u>CAS#</u>	<u>Wt%</u>	<u>OSHA-PEL</u>	<u>ACGIH-TLV</u>	<u>LC 50</u>	<u>LD 50</u>
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None by WHMIS/OSHA criteria.

SECTION III - PHYSICAL DATA

Boiling Point (°C): Not applicable	Specific Gravity (H₂O = 1): Not available
Vapour Pressure (mm Hg): Not applicable	% Volatile (Wt %): Not available
Vapour Density (Air = 1): Not applicable	Evaporation Rate (Ether = 1): Not applicable
Solubility in Water: Not available	pH (100%): Not available
Physical State: Solid	Viscosity: Not applicable
Appearance: Off-white powder	Odour Threshold (ppm): Not available

SECTION IV - FIRE AND EXPLOSION DATA

Flammability: Not flammable by WHMIS/OSHA criteria.
Flash Point (°C, TCC): None **LEL:** Not applicable **UEL:** Not applicable
Hazardous Combustion Products: May include and are not limited to oxides of carbon.
Autoignition Temperature (°C): Not applicable
Means of Extinction: Treat for surrounding material.
Special Fire Hazards: Firefighters should wear self-contained breathing apparatus.

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SECTION V - REACTIVITY DATA

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Conditions for Chemical Instability: Stable.

Incompatible Materials: None known.

Reactivity, and Under What Conditions: Not available.

Hazardous Decomposition Products: May include and are not limited to oxides of carbon when heated to decomposition.

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SECTION VI - TOXICOLOGICAL PROPERTIES

=====

Route of Entry: Eye, Skin contact, Inhalation, Ingestion.

EFFECTS OF ACUTE EXPOSURE:

Eye: May cause irritation upon direct contact.

Inhalation: May cause respiratory tract irritation.

Ingestion: May cause stomach distress, nausea or vomiting if ingested in large quantities.

EFFECTS OF CHRONIC EXPOSURE:

Skin: Prolonged or repeated exposure can cause drying, defatting and dermatitis.

Irritancy: Non-hazardous by WHMIS/OSHA criteria.

Respiratory Tract Sensitization: No data available.

Carcinogenicity: Non-hazardous by WHMIS/OSHA criteria.

Teratogenicity, Mutagenicity, Reproductive Effects: No data available.

Synergistic Materials: Not available.

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SECTION VII- PREVENTATIVE MEASURES

=====

Gloves: No requirements beyond standard industrial hygiene practices.

Eye Protection: No requirements beyond standard industrial hygiene practices.

Respiratory Protection: Not normally required if good ventilation is maintained.

Other Protective Equipment: As required by employer code.

Engineering Controls: General ventilation normally adequate.

Leak and Spill Procedure: Before attempting clean up, refer to hazard data given above. Use broom or dry vacuum to

collect material for proper disposal without raising dust. Rinse area with water. Prevent large spills from entering sewers or

waterways. Contact emergency services and supplier for advice.

Waste Disposal: Review federal, state/provincial, and local government requirements prior to disposal.

Storage and Handling Requirements: Keep out of reach of children. Store in a closed container away from incompatible materials.

=====

SECTION VIII - FIRST AID

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Eye: Flush with cool water. Remove contact lenses, if applicable, and continue flushing. Obtain medical attention if irritation

persists.

Skin: Brush away excess of dry material. Flush with water. Obtain medical attention if irritation persists.

Inhalation: If symptoms develop move victim to fresh air. If symptoms persist, obtain medical attention.

Ingestion: Do not induce vomiting. Rinse mouth with water then drink one or two glasses of water. Obtain medical attention.

Never give anything by mouth if victim is unconscious, or is convulsing.

=====

SECTION IX - PREPARATION INFORMATION

=====

Date: 2002/01/24

MSDS Prepared by: KKK SYNERGIZE INC.

Telephone: 1 - 519 -438-9374

=====

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Bureau 550
Laval, Quebec, H7M 3Y2
Telephone: 450 – 972-6291

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SECTION III - PHYSICAL DATA

Boiling Point (°C): Not applicable	Specific Gravity (H2O = 1): Not available
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Vapour Density (Air = 1): Not applicable	Evaporation Rate (Ether = 1): Not applicable
Solubility in Water: Not available	pH (100%): Not available
Physical State: Solid	Viscosity: Not applicable
Appearance: Off-white powder	Odour Threshold (ppm): Not available

SECTION IV - FIRE AND EXPLOSION DATA

Flammability: Not flammable by WHMIS/OSHA criteria.
Flash Point (°C, TCC): None **LEL:** Not applicable **UEL:** Not applicable
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Synergistic Materials: Not available.

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Ingestion: Do not induce vomiting. Rinse mouth with water then drink one or two glasses of water. Obtain medical attention.

Never give anything by mouth if victim is unconscious, or is convulsing.

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SECTION IX - PREPARATION INFORMATION

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Date: 2002/01/24
Telephone: 1 - 519 -438-9374

MSDS Prepared by: KGK SYNERGIZE INC.

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[Code of Federal Regulations]
[Title 21, Volume 1, Parts 1 to 99]
[Revised as of April 1, 2000]
From the U.S. Government Printing Office via GPO Access
[CITE: 21CFR73.75]

[Page 337-338]

TITLE 21--FOOD AND DRUGS

PART 73--LISTING OF COLOR ADDITIVES EXEMPT FROM CERTIFICATION--Table of Contents

Subpart A--Foods

Sec. 73.75 Canthaxanthin.

(a) Identity. (1) The color additive canthaxanthin is <greek-b>-carotene-4,4'-dione.

(2) Color additive mixtures for food use made with canthaxanthin may contain only those diluents that are suitable and that are listed in this subpart as safe for use in color additive mixtures for coloring foods.

(b) Specifications. Canthaxanthin shall conform to the following specifications and shall be free from impurities other than those named to the extent that such other impurities may be avoided by good manufacturing practice:

Physical state, solid.

1 percent solution in chloroform, complete and clear.

Melting range (decomposition), 207 deg.C. to 212 deg.C. (corrected).

Loss on drying, not more than 0.2 percent.

Residue on ignition, not more than 0.2 percent.

Total carotenoids other than trans-canthaxanthin, not more than 5 percent.

Lead, not more than 10 parts per million.

Arsenic, not more than 3 parts per million.

Mercury, not more than 1 part per million.

Assay, 96 to 101 percent.

(c) Use and restrictions. (1) The color additive canthaxanthin may be safely

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used for coloring foods generally subject to the following restrictions:

(i) The quantity of canthaxanthin does not exceed 30 milligrams per pound of solid or semisolid food or per pint of liquid food; and

(ii) It may not be used to color foods for which standards of identity have been promulgated under section 401 of the act unless added color is authorized by such standards.

(2) Canthaxanthin may be safely used in broiler chicken feed to enhance the yellow color of broiler chicken skin in accordance with the

following conditions: The quantity of canthaxanthin incorporated in the feed shall not exceed 4.41 milligrams per kilogram (4 grams per ton) of complete feed to supplement other known sources of xanthophyll and associated carotenoids to accomplish the intended effect.

(3) Canthaxanthin may be safely used in the feed of salmonid fish in accordance with the following prescribed conditions:

(i) Canthaxanthin may be added to the fish feed only in the form of a stabilized color additive mixture;

(ii) The color additive is used to enhance the pink to orange-red color of the flesh of salmonid fish; and

(iii) The quantity of color additive in feed shall not exceed 80 milligrams per kilogram (72 grams per ton) of finished feed.

(d) Labeling requirements. (1) The labeling of the color additive and any mixture prepared therefrom intended solely or in part for coloring purposes shall conform to the requirements of Sec. 70.25 of this chapter.

(2) For purposes of coloring fish, the labeling of the color additive and any premixes prepared therefrom shall bear expiration dates (established through generally accepted stability testing methods) for the sealed and open container, other information required by Sec. 70.25 of this chapter, and adequate directions to prepare a final product complying with the limitations prescribed in paragraph (c)(3) of this section.

(3) The presence of the color additive in finished fish feed prepared according to paragraph (c)(3) of this section shall be declared in accordance with Sec. 501.4 of this chapter.

(4) The presence of the color additive in salmonid fish that have been fed feeds containing canthaxanthin shall be declared in accordance with Secs. 101.22(b), (c), and (k)(2), and 101.100(a)(2) of this chapter.

(e) Exemption from certification. Certification of this color additive is not necessary for the protection of the public health, and therefore batches thereof are exempt from the certification requirements of section 721(c) of the act.

[42 FR 15643, Mar. 22, 1977, as amended at 50 FR 47534, Nov. 19, 1985; 63 FR 14817, Mar. 27, 1998]

Color Additive Regulations

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[Code of Federal Regulations]
[Title 21, Volume 1, Parts 1 to 99]
[Revised as of April 1, 2000]
From the U.S. Government Printing Office via GPO Access
[CITE: 21CFR73.1075]

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TITLE 21--FOOD AND DRUGS

PART 73--LISTING OF COLOR ADDITIVES EXEMPT FROM CERTIFICATION--Table of Contents

Subpart B--Drugs

Sec. 73.1075 Canthaxanthin.

(a) Identity and specifications. (1) The color additive canthaxanthin shall conform in identity and specifications to the requirements of Sec. 73.75(a)(1) and (b).

(2) Color additive mixtures for ingested drug use made with canthaxanthin may contain only those diluents that are suitable and that are listed in this subpart as safe in color additive mixtures for coloring ingested drugs.

(b) Uses and restrictions. Canthaxanthin may be safely used for coloring ingested drugs generally in amounts consistent with good manufacturing practice.

(c) Labeling requirements. The label of the color additive and of any mixtures prepared therefrom intended solely or in part for coloring purposes shall conform to the requirements of Sec. 70.25 of this chapter.

(d) Exemption from certification. Certification of this color additive is not necessary for the protection of the public health, and therefore batches thereof are exempt from the certification requirements of section 721(c) of the act.

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[Revised as of April 1, 2000]
From the U.S. Government Printing Office via GPO Access
[CITE: 21CFR73.35]

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TITLE 21--FOOD AND DRUGS

PART 73--LISTING OF COLOR ADDITIVES EXEMPT FROM CERTIFICATION--Table of Contents

Subpart A--Foods

Sec. 73.35 Astaxanthin.

(a) Identity. (1) The color additive astaxanthin is 3, 3'-dihydroxy-<greek-b>, <greek-b>-carotene-4, 4'-dione.

(2) Astaxanthin may be added to the fish feed only as a component of a stabilized color additive mixture. Color additive mixtures for fish feed use made with astaxanthin may contain only those diluents that are suitable and are listed in this subpart as safe for use in color additive mixtures for coloring foods.

(b) Specifications. Astaxanthin shall conform to the following specifications and shall be free from impurities other than those named to the extent that such impurities may be avoided by good manufacturing practice:

Physical state, solid.

0.05 percent solution in chloroform, complete and clear.

Absorption maximum wavelength 484-493 nanometers (in chloroform).

Residue on ignition, not more than 0.1 percent.

Total carotenoids other than astaxanthin, not more than 4 percent.

Lead, not more than 5 parts per million.

Arsenic, not more than 2 parts per million.

Mercury, not more than 1 part per million.

Heavy metals, not more than 10 parts per million.

Assay, minimum 96 percent.

(c) Uses and restrictions. Astaxanthin may be safely used in the feed of salmonid fish in accordance with the following prescribed conditions:

(1) The color additive is used to enhance the pink to orange-red color of the flesh of salmonid fish.

(2) The quantity of color additive in feed is such that the color additive shall not exceed 80 milligrams per kilogram (72 grams per ton) of finished feed.

(d) Labeling requirements. (1) The labeling of the color additive and any premixes prepared therefrom shall bear expiration dates for the sealed and open container (established through generally accepted stability testing methods), other information required by Sec. 70.25 of this chapter, and adequate directions to prepare a final product

complying with the limitations prescribed in paragraph (c) of this section.

(2) The presence of the color additive in finished fish feed prepared according to paragraph (c) of this section shall be declared in accordance with Sec. 501.4 of this chapter.

(3) The presence of the color additive in salmonid fish that have been fed feeds containing astaxanthin shall be declared in accordance with Secs. 101.22(k)(2) and 101.100(a)(2) of this chapter.

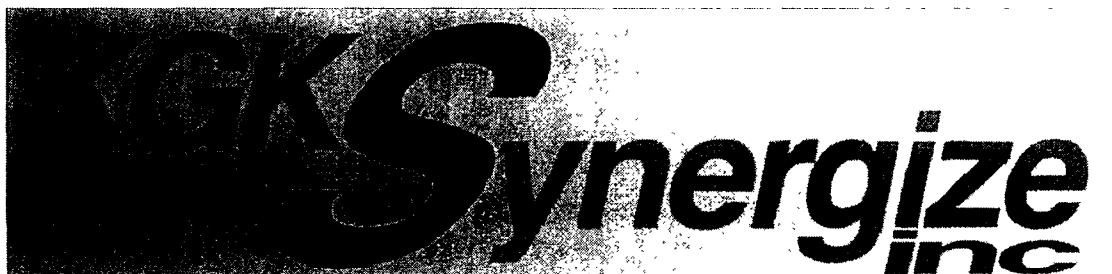
(e) Exemption from certification. Certification of this color additive is not necessary for the protection of the public health, and therefore batches thereof are exempt from the certification requirements of section 721(c) of the act.

[60 FR 18738, Apr. 13, 1995]

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Color Additive Regulations

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ANALYTICAL REPORT

Client	Louis Lappointte
Company	Neptune Technologies & Bioresources Inc.
Date Received	November 14, 2001.
Date Reported	November 22, 2001.

Analysis of astaxanthin and canthaxanthin was performed on the following samples submitted with your order

Sample name	Type of sample
800	Marine oil
801	Marine oil

The following reference method was used

Enzymatic hydrolysis using Lipase from *Candida rugosa* followed by extraction and high performance liquid chromatography.

References

Xinia et al. J, Food Comp. Anal. 13 (2000), 179-187.

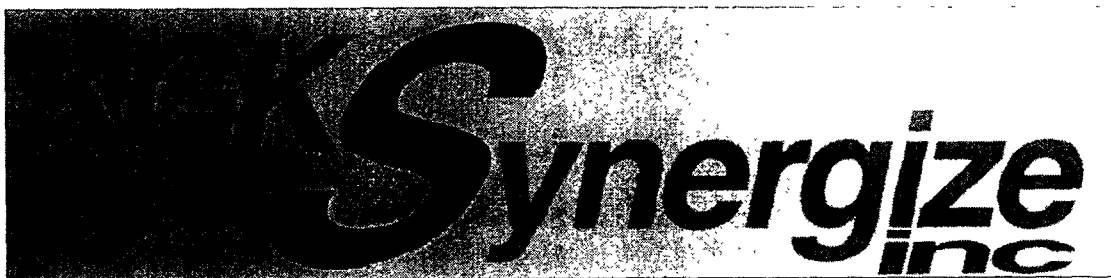
	800	801
Canthaxanthin µg/g	389.3	454.2
Astaxanthin µg/g	168.7	122.3

This report has been approved by:

A handwritten signature in black ink, appearing to read "Elzbieta M. Kurowska".

Elzbieta M. Kurowska, Ph.D.
Vice President, Research & Development

Suite 1030, One London Place, 255 Queens Avenue, London, ON N6A 5R8 Canada Tel: (519) 438-9374
or (519) 438-8916 Fax: (519) 438-8314 E-mail: kurowska@kgksynergize.com www.kgksynergize.com



ANALYTICAL REPORT

Client	Louis Lappointte
Company	Neptune Technologies & Bioressources Inc.
Date Received	November 14, 2001.
Date Reported	November 23, 2001.

Trace metal analysis was performed on the following samples submitted with your order

Sample name	Type of sample
800	Marine oil
801	Marine oil

The following reference method has been used

Digestion by nitric acid and hydrogen peroxide followed by ICP-MS (Inductively Coupled Plasma Mass Spectrometry)

This report has been approved by:

A handwritten signature in black ink, appearing to read 'Elzbieta M. Kurowska'.

Elzbieta M. Kurowska, Ph.D.
Vice President, Research & Development

	800	801
Lead $\mu\text{g/g}$	0.005	0.002
Sodium mg/g	0.0023	0.019
Magnesium $\mu\text{g/g}$	0.06	0.03
Iron $\mu\text{g/g}$	0.87	0.41
Copper $\mu\text{g/g}$	0.05	0.09
Zinc $\mu\text{g/g}$	0.06	0.04
Selenium $\mu\text{g/g}$	0.05	0.02
Potassium mg/g	0.015	0.024

**BIOPHARM inc.**

3885, boul. Industriel, Laval Québec

Canada H7L 4S3

Tél. (450) 663-6724

Téléc. (450) 975-8111

Certificate of analysis

NCA : N18-020408-37

Req : -

Code Client : N18

Version : 1

Our quality system is certified according to ISO-9002 standard

Printed : 2002/04/29

Received : 2002/04/08

Date : 2002/04/29

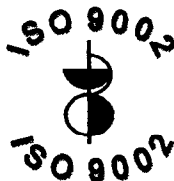
(yyyy/mm/dd)

Page : 1 of 2

Neptune Technologies/Tina Sampalis

500, boul. St-Martin Ouest

Laval, Québec H7M 3Y2

**RESULT****Sample :** MARINE OIL**Section :** 1**Lot Not :** WA1303**Gabarit :** Raw material**Description :** Reddish opaque oily liquid having a fishy odor

Complies

TEST	METHOD	SPECIFICATION	
Cholesterol	JAOAC Vol 76, No. 4 (GLC)	Report (g/100 g)	1.3
Vitamin A	HPLC	Report (UI/g)	809.2
Vitamin E	HPLC	Report (UI/g)	1.01
Free fatty acid profile	AOCS Ce 1b-89 (GLC)	Report (%)	(2)
Acid value	GLC	Report (ppm)	< 100
Free fatty acids	USP <401> (1)	Report (mg KOH/g)	29.7
Phosphatidyl inositol	(TLC)	Report (g/100 g)	< 2.5
Phosphatidyl choline	(TLC)	Report (g/100 g)	5.0
Phosphatidyl ethanolamine	(TLC)	Report (g/100 g)	48.5
Phosphatidyl serine	(TLC)	Report (g/100 g)	< 2.5
Sphingomyelin	(TLC)	Report (g/100 g)	< 2.4
Total phospholipids	Colorimetry	Report (g/100 g)	53.5
Iodine value	A.O.C.S. Cd. 1-25	Report (mg I/100g)	3.56
Oil stability index	A.O.C.S. Cd. 12b. 92	Induction time converted to the reference temperature of 97.8°C (hrs)	> 50
p-Anisidine value	A.O.C.S. Cd. 18.90	Report	1.98
Peroxide value	A.O.C.S. Cd. 8b. 90	Report (meq peroxide/kg)	< 0.1
Saponification index	A.O.C.S. Cd. 3.25	Report (mg KOH/g)	172.1
Moisture and volatile matter	Dried 16 h at 60°C under vacuum	Report (%)	0.61

(1) Under Acid Value, (2) (100 - % ash), USP Current Edition

Verified by : **Sylvain Mandeville, Ph.D., Scientific Director**Approved by : **Luce Blanchard, Chemist**

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Télec. (450) 975-8111

Certificate of analysis

NCA : N18-020408-37

Req : -

Code Client : N18

Version : 1

Our quality system is certified according to ISO-9002 standard

Neptune Technologies/Tina Sampalis

500, boul. St-Martin Ouest

Laval, Québec H7M 3Y2



Printed : 2002/04/29

Received : 2002/04/08

Date : 2002/04/29

(yyyy/mm/dd)

Page : 2 of 2

RESULT

Sample : MARINE OIL

Viscosity	FP-78	Report (cst)	927.2
Ash (total inorganic substances)	KGK (2h at 600°C)	Report (%)	4.09
Total protein	CA-126-050	Report (%)	6.08
Total lipids	CG-118-039	Report (%)	79.3
Assay of Sodium (AAS)	CM-109-125	Report (mg/100 g)	386
Assay of Zinc (AAS)	CM-109-125	Report (mg/100 g)	0.66
Assay of Potassium (AAS)	CM-109-125	Report (mg/100 g)	207
Assay of Calcium (AAS)	CM-109-125	Report (mg/100 g)	0.60
Assay of Selenium (AAS)	CM-109-215	Report (mg/100 g)	< 3.1
Assay of Aluminium (AA)	CM-109-125	Report (mg/100 g)	7.45
Assay of Copper (AA)	CM-109-125	Report (mg/100 g)	0.17
Assay of Manganese (AAS)	CM-109-125	Report (mg/100 g)	< 0.31

(1) Under Acid Value, (2) (100 - % ash); USP Current Edition

Verified by : **Sylvain Mandeville, Ph.D., Scientific Director**

Approved by : **Lucie Blanchard, Chemist**

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CERTIFICATE OF ANALYSIS



NCA: N18-020408-37
 Req: -
 Code client: N18
 Version: 1

Neptune Technologies
 500, boul. St-Martin Ouest
 Laval, Québec H7M 3Y2



Reçu: 2002/04/08
 Date: 2002/04/29
 Section: 2

Page 1 of 2

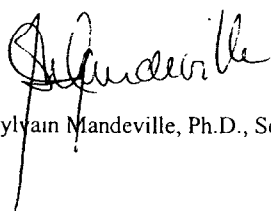
Échantillon: Marine Oil, lot WA1303

FATTY ACIDS	AREA %	g/100 g of sample
C 14 :0	6.10	4.84
C 14 :1	0.15	0.12
C 15 :0	0.34	0.27
C 16 :0	19.55	15.50
C 16 :1	5.89	4.67
C 18 :0	0.82	0.65
C 18 :1	12.77	10.13
C 18 :2n-6	1.47	1.17
C 18 :4n-6	0.05	0.04
C 18 :3n-3	0.72	0.57
C 18 :4n-3	1.11	0.88
C 20 :0	0.08	0.06
C 20 :1	0.38	0.30
C 20 :2n-6	0.13	0.10
C 20 :4n-6	0.65	0.52
C 20 :4n-3	0.47	0.37

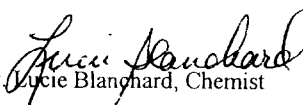
WARNEX | BIOPHARM | NORSCIENCE | GENEVISION |

3885, boul Industriel, Laval (Québec), Canada H7L 4S3
 Tel (450) 663-6724 Fax (450) 669-2784 www.warnex.ca

C 20 :5n-3 (EPA)	23.06	18.30
C 22 :0	0.25	0.20
C 21 :5n-3	7.12	5.64
C 23 :0	1.21	0.96
C 22 :5n-3	0.12	0.09
C 24 :0	1.09	0.87
C 22 :6n-3	12.09	9.58
C 24 :1	0.32	0.25



Verified by: Sylvain Mandeville, Ph.D., Scientific Director



Approved by: Lucie Blanchard, Chemist



SGS Laboratoires d'Analyses Agro-Alimentaires
Une Division de SGS Canada Inc.

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TEST REPORT

NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

ATTENTION OF M. LUC RAINVILLE

RECEPTION DATE : 01 11 16
LABORATORY NUMBER : 160080544R
NUMBER OF SAMPLES : 5
REPORT DATE : 01 12 05
PAGE : 1 DE 1
ANALYSIS REPORT : 01 11 30

SAMPLES		1	2	3	4	5	
		KRILL 15-11-01	KRILL 15-11-01	KRILL 15-11-01	KRILL 15-11-01	KRILL 15-11-01	
ANALYSIS							
ACIDITY (CITRIC ACID)	G/100G	0.02	0.03	0.03	0.03	0.03	0.028
INTERSPACE WATER	G/100G	9.48	9.43	9.61	16.96	11.48	
SULFITES	PPM	< 2	< 2	< 2	< 2	< 2	< 2
MOISTURE	G/100G	81.9	81.2	80.8	80.9	80.9	81.14
ASH	G/100G	3.0	2.9	3.0	3.0	3.0	2.78
PROTEINS	G/100G	13.2	13.6	13.6	14.2	14.1	13.74
FAT	G/100G	2.0	2.3	2.2	2.3	2.5	2.26
CARBOHYDRATES	G/100G	0.0	0.0	0.3	0.0	0.0	0.00
ENERGY PER 100 G	CALORIES	71	75	75	78	78	75.4

JACQUELINE BEAUPRÉ, SUPERVISEURE - CHIMIE
neptuneCHEMmas
FAX : 450-972-6351
FAX: 450-979-0660

01 12 05

RÉVISION 1

This report is issued by the Company under its General Conditions for Inspection and Testing Services (copy available upon request). The issuance of this report does not exonerate buyers or sellers from exercising all their rights and discharging all their liabilities under the Contract of Sale. Stipulations to the contrary are not binding on the Company. The Company's responsibility under this report is limited to proven negligence and will in no case be more than ten times the amount of the fees or commission. Except by special arrangement, samples, if drawn, will not be retained by the Company for more than one month.

RAPPORT D'ANALYSE

Date 25 Février 2002

No de lot 12-2-02

Nom du produit : Krill lyophilisé en poudre

Description : Poudre couleur rosée, forte odeur de poisson.

Conditions d'entreposage :

TESTS	METHODES	SPECIFICATIONS	RESULTATS
Humidité	O'Haus	< 5%	1.1%
Microbiologie			
Compte Total	U.S.P.		500/g
Levures	U.S.P.		< 100/g
Moisissures			< 10/g
Coliformes Totaux	A.P.H.A.		< 100/g
S. Aureus	A.P. H.A.		absence
E. Coli 0157	U.S.P.		absence
Salmonella sp.	U.S.P.		absence

Analyste : Ahmed Elouadi

Q



SGS Laboratoires d'Analyses Agro-Alimentaires
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185 boul. Brunswick
Pointe-Claire, Québec
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Télécopieur (514) 630-6095

NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

À L'ATTENTION DE MME. TINA SAMPALIS

DATE DE RÉCEPTION: 02-03-06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 7 DE 7
DATE D'ANALYSE: 02-03-06

ÉCHANTILLONS:

1	2
A-SGS-1	LK-SGS-1
EXTRACTION #114, 44IÈME SÉCHAGE	KRILL LYO EN POUDRE, LOT: 180202
DU 14-02-2002, EMBALÉ LE 15-02-2002	POIDS NET 250G

MÉTHODE:

BACTÉRIES TOTALES /G	MFHPB-33	<100	1,400
COLIFORMES TOTAUX /G	MFHPB-34	<10	<10
E.COLI /G	MFHPB-34	<10	<10
STAPH. AUREUS /G	MFHPB-21	<10	<10
LEVURES /G	MFHPB-22	<10	<10
MOISSISURES /G	MFHPB-22	<10	<10
SALMONELLES /G	MFHPB-20	NON DÉTECTÉE	NON DÉTECTÉE
PSEUDOMONAS SPP.		<50	50

D. Beaupré pour.

DANIÈLE LESSARD
SUPERVISEURE DES SERVICES TECHNIQUES ET DU CQ
neptuneMICmas
FAX: 450-972-6351

02 03 26

Le présent rapport a été émis par la Société conformément à ses Conditions Générales pour les prestations de services de contrôle et d'analyse (copie disponible sur demande). L'émission du présent rapport ne dispense pas les acheteurs ou les vendeurs d'exercer tous leurs droits et d'exécuter toutes leurs obligations liés au contrat de vente. Toute stipulations contraires n'engagent pas la Société. La responsabilité de la Société relative au présent rapport est limitée à la négligence prouvée et n'excèdera en aucun cas dix fois le montant des honoraires ou de la commission. Sauf disposition spéciale, les échantillons, s'il en a été prélevés, ne seront pas conservés par la Société au delà d'une période de un mois.



NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

DATE DE RÉCEPTION: 02 03 06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 5 DE 7
DATE D'ANALYSE: 02 03 11

PRODUIT: CONCENTRÉ DE PROTÉINES A-SGS-1

		CONTENU	CONTENU	%			CONTENU	CONTENU	%
DESCRIPTION		uMOL/gr	mg/gr		DESCRIPTION		uMOL/gr	mg/gr	
1	TAURINE	81	10.1	2.15	21	ISOLEUCINE	161	21.1	4.48
2	AC. ASPARTIQUE	312	41.5	8.81	22	LEUCINE	269	35.3	7.49
3	HYDROXYPROLINE				23	AC.ARGININOSUCCINIQUE			
4	THRÉONINE	188	22.4	4.75	24	TYROSINE	131	23.7	5.04
5	SÉRINE	120	12.6	2.68	25	B-ALANINE			
6	ASPARAGINE				26	PHÉNYLALANINE	165	27.3	5.78
7	AC. GLUTAMIQUE	392	57.7	12.24	27	AC. B-AMINO-ISOBUTYRIQUE			
8	GLUTAMINE				28	HOMOCYSTINE			
9	SARCOSINE				29	AC Y-AMINOBUTYRIQUE			
10	AC. AMINOADIPIQUE				30	ORNITINE	46	6.1	1.29
11	PROLINE	199	22.9	4.86	31	LYSINE	282	41.2	8.75
12	GLYCINE	329	24.7	5.24	32	1-MÉTHYLHISTIDINE			
13	ALANINE	282	25.1	5.33	33	HISTIDINE	69	10.7	2.27
14	CITRULLINE	1			34	3-MÉTHYLHISTIDINE			
15	AC. AMINO-D-BUTYRIQUE				35	CARNOSINE			
16	VALINE	211	24.7	5.24	36	ARGININE	218	38.0	8.06
17	CYSTINE	30	7.2	1.53	37	TRYPTOPHANE	34	6.9	1.47
18	MÉTHIONINE	80	11.9	2.53					
19	HOMOCITRULLINE								
20	CYSTATHIONINE								
Total		3600	471.3	100.0					

02 03 28

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SGS Laboratoires d'Analyses Agro-Alimentaires
Une Division de SGS Canada Inc.

185 boul. Brunswick
Pointe-Claire, Québec
Canada H9R 4Z1
Téléphone (514) 630-6093
Télécopieur (514) 630-6095

RAPPORT D'ESSAIS

NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

DATE DE RÉCEPTION: 02 03 06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 4 DE 7
DATE D'ANALYSE: 02 03 11

À L'ATTENTION DE MME. TINA SAMPALIS

ÉCHANTILLONS	SPECIFICATIONS	¹ CONCENTRÉ DE PROTÉINES A-SGS-1	² CONCENTRÉ DE PROTÉINES LK-SGS-1
		ANALYSES	
ALUMINIUM	PPM	46	43
BARIUM	PPM	5.0	4.6
BORON	PPM	21	18
CADMIUM	PPM	0.6	0.4
CALCIUM	PPM	22600	17300
CHROMIUM	PPM	1.1	1.2
COPPER	PPM	114	92.2
FLUORIDE	PPM	376	411
IRON	PPM	54.6	45.2
LEAD	PPM	< 1	< 1
MAGNESIUM	PPM	6940	5010
MANGANESE	PPM	2.8	2.2
MERCURY	PPM	< 0.1	< 0.1
PHOSPHORUS	PPM	15200	13500
POTASSIUM	PPM	8290	14010
SELENIUM	PPM	5.2	4.4
SODIUM	PPM	19600	29300
STRONTIUM	PPM	346	260
SULPHUR	PPM	12600	11500
ZINC	PPM	74	53

JACQUELINE BEAUPRÉ, SUPERVISEURE - CHIMIE
neptuneCHEMmas
FAX: 450-972-6351

02 03 26

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H7M 3Y2

DATE DE RÉCEPTION: 02 03 06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 2 DE 7
DATE D'ANALYSE: 02 03 11

À L'ATTENTION DE MME. TINA SAMPALIS

ÉCHANTILLONS		1	2
		CONCENTRÉ DE PROTÉINES A-SGS-1	CONCENTRÉ DE PROTÉINES LK-SGS-1
ANALYSES			
CHOLESTEROL	MG/100G	26	528
SATURATED FATTY ACIDS	G/100G	0.42	1.93
MONOUNSATURATED	G/100G	0.38	1.68
POLYUNSATURATED	G/100G	0.33	1.95
TRANS	G/100G	< 0.01	< 0.01
EPA	G/100G	0.15	0.99
DHA	G/100G	0.14	0.62
PC	G/100G	0.31	3.32
PI	G/100G	0.04	0.04
PS	G/100G	0.05	0.07
PE	G/100G	0.16	0.58
SM	G/100G	0.05	0.16

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RAPPORT D'ESSAIS

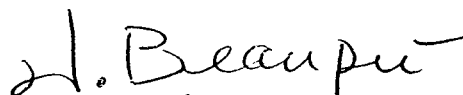
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500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

DATE DE RÉCEPTION: 02 03 06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 1 DE 7
DATE D'ANALYSE: 02 03 11

À L'ATTENTION DE MME. TINA SAMPALIS

ÉCHANTILLONS		1	2
		CONCENTRÉ DE PROTÉINES A-SGS-1	CONCENTRÉ DE PROTÉINES LK-SGS-1
ANALYSES			
MOISTURE	G/100G	2.76	2.92
FAT	G/100G	1.13	5.54
PROTEIN	G/100G	81.71	73.39
ASH	G/100G	14.07	15.77
CARBOHYDRATES	G/100G	0.33	2.38
ENERGY	CAL/100G	338	353
ENERGY	KJ/100G	1436	1493
OXYCAROTENOIDS*	MG/100G	0.7	11.0
ACETONE	PPM	300	--

* Astaxanthine & canthaxanthine


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neptuneCHEMmas
FAX: 450-972-6351

02 03 26

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RAPPORT D'ESSAIS

NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
500, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

DATE DE RÉCEPTION: 02 03 08
NUMERO DE LABORATOIRE: 180083519R
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 05 08
PAGE: 3 DE 7
DATE D'ANALYSE: 02 03 11

À L'ATTENTION DE MME. TINA SAMPALIS

ÉCHANTILLONS	SPECIFICATIONS	1	2
		CONCENTRÉ DE PROTÉINES A-SGS-1	CONCENTRÉ DE PROTÉINES LK-SGS-1
ANALYSES			
VITAMIN A (RETINOL)	UI/100G	275	7100
VITAMIN E	UI/100G	16	82
VITAMIN D	UI/100G	<10	<10
RIBOFLAVIN (B2)	MG/100G	8.6	23.8
THIAMINE (B1)	MG/100G	< 1	< 1
VITAMIN H6	MG/100G	< 0.1	< 0.1
CYANOCOBALAMINE (B12)	UG/100G	< 10	< 10
FOLIC ACID	MG/100G	0.2	1.7
PANTOTHENIC ACID	MG/100G	102	676
BIOTIN	PPM	92	<10
NIACIN	MG/100G	87.6	187.3

MILLIE CHEN
COORDONNATRICE DE LABORATOIRE
neptuneCHEMins
FAX: 450-972-6351

02 05 08

Révision 2

Le présent rapport a été émis par la Société conformément à ses Conditions Générales pour les prestations de services de contrôle et d'analyse (copie disponible sur demande). L'émission du présent rapport ne dispense pas les acheteurs ou les vendeurs d'exercer toute leur diligence et d'acquiescer toutes leurs obligations liées au contrat de vente. Toute stipulation contraire n'engageant pas la Société. La responsabilité de la Société relative au présent rapport est limitée à la négligence prouvée et n'excède en aucun cas dix fois le montant des honoraires ou de la commission. Sauf disposition spéciale, les échantillons, s'il en a été prélevés, ne seront pas conservés par la Société au-delà d'une période de un mois.



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RAPPORT D'ESSAIS

NEPTUNE TECHNOLOGIES & BIORESSOURCES INC.
600, St-Martin ouest, bureau 550
Laval, Québec
H7M 3Y2

DATE DE RÉCEPTION: 02 03 06
NUMERO DE LABORATOIRE: 160083519
NOMBRE D'ÉCHANTILLONS: 2
DATE DE RAPPORT: 02 03 26
PAGE: 4 DE 7
DATE D'ANALYSE: 02 03 11

À L'ATTENTION DE MME. TINA SAMPALIS

ÉCHANTILLONS		1	2
		CONCENTRÉ	CONCENTRÉ
		DE PROTÉINES	DE PROTÉINES
		A-SGS-1	LK-SGS-1
ANALYSES			
SPECIFICATIONS			
ALUMINIUM	PPM	46	43
BARIUM	PPM	5.0	4.6
BORON	PPM	21	18
CADMIUM	PPM	0.6	0.4
CALCIUM	PPM	22600	17300
CHROMIUM	PPM	1.1	1.2
COPPER	PPM	114	92.2
FLUORIDE	PPM	376	411
IRON	PPM	54.6	45.2
LEAD	PPM	< 1	< 1
MAGNESIUM	PPM	6940	5010
MANGANESE	PPM	2.8	2.2
MERCURY	PPM	< 0.1	< 0.1
PHOSPHORUS	PPM	15200	13500
POTASSIUM	PPM	8290	14010
SELENIUM	PPM	5.2	4.4
SODIUM	PPM	19600	29300
STRONTIUM	PPM	346	260
SULPHUR	PPM	12600	11500
ZINC	PPM	74	53

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Aquasearch, Inc.**Technical Report*****Haematococcus Pluvialis and Astaxanthin Safety For Human Consumption***

Safety for human consumption of *Haematococcus pluvialis* algal meal and astaxanthin has been demonstrated by a number of studies:

- A recent 28-day rat study with *Haematococcus pluvialis* dry algal meal, produced by Aquasearch's proprietary technology, demonstrated that there was no observed sub-acute toxicity at a daily dose of 50 mg/kg body weight, corresponding to 3,500 mg algal meal per 70-kg body weight of a typical adult man.
- No lethality was seen for *Haematococcus pluvialis* algae at doses up to 5000 mg/kg body weight, in an earlier, 13-day, single-dose (acute-toxicity), rat study.
- A human safety study demonstrated that daily ingestion of up to 1,140 mg Aquasearch's *Haematococcus pluvialis* algal meal, for 29 days, did not result in any safety concern.
- A recent sub-acute rat toxicity with Aquasearch's *Haematococcus pluvialis* algal meal, showed no signs of toxicity, after dosing rats with up to 1.15 mg astaxanthin per kg body weight per day (equivalent to 80.5 mg astaxanthin per 70-kg body weight) for 28 consecutive days.
- In a human safety study with Aquasearch's algal astaxanthin, no sign of toxicity or safety concern was observed, when volunteers ingested up to 19.25 mg astaxanthin per day for 29 days, while an earlier human study failed to find any harmful effect from 14.4 mg/day astaxanthin ingestion for two weeks.
- Pure astaxanthin (up to 80 mg/kg feed), is Generally Considered As Safe by FDA, for use in salmon diets. This can result in astaxanthin deposition of 10 to 15 mg/kg in salmon fillets. Levels of astaxanthin naturally occurring in wild-caught seafood, and dietary studies on carotenoids, seafood, and salmon,

also suggest that a daily serving of 5 mg astaxanthin, corresponding to 125 g of wild-caught Sockeye salmon fillet or less than 100 g of krill, is safe.

- The proprietary technology and quality control developed by Aquasearch to produce *Haematococcus pluvialis* algal meal, ensure that the product meets dietary supplement safety standards.

Conclusion: A supplement containing 5 mg astaxanthin derived from 250 mg, or less, of Aquasearch's *Haematococcus pluvialis* algal meal is safe for daily human consumption.

Aquasearch's proprietary technology allows the production of a high quality algal meal containing 2% total astaxanthin or more. It is therefore a very good source of natural astaxanthin, a carotenoid pigment and biological antioxidant widely encountered in nature. Safety for human consumption of astaxanthin and *Haematococcus pluvialis* algae has been demonstrated by a number of studies.

1. Toxicity studies

1.1. *Haematococcus* algae.

1.1.1. Human safety study

In a recent clinical safety study with Aquasearch's *Haematococcus pluvialis* algal meal, 33 human volunteers (15 males and 18 females, age 28 to 62) ingested on a daily basis, for 29 consecutive days, either a Low Dose supplement containing 228 mg algal meal and 3.85 mg astaxanthin, or a High Dose supplement containing 1140 mg algal meal and 19.25 mg astaxanthin.¹

Volunteers underwent a complete medical examination before, during and at the end of the study. The physician, examined specifically, but not exclusively, the weight, skin coloration, general appearance, blood pressure, vision and eye, (near and distant vision, color vision, depth perception, eye condition), ears and nose, mouth, throat and teeth, chest and lungs, and reflexes, for each volunteer.

This medical examination was complemented by extensive urine analyses and blood analyses (cell counts, hemoglobin, liver enzyme activity indicators, and other blood parameters) (Table 1). No ill effects or toxicity from ingestion of the supplement were

observed, confirming the absence of toxicity of Aquasearch's *Haematococcus pluvialis* algal meal.

1.1.2. Rat toxicity studies

Absence of toxicity of *Haematococcus pluvialis* has also been demonstrated in rats and mice, widely accepted animal models for safety assessment of human dietary supplements.

A 28-day sub-acute rat toxicity study, with *Haematococcus pluvialis* algal meal produced with Aquasearch's proprietary technology, failed to find any sign of toxicity of this algal meal.² Three groups of 20 rats each (10 males/10 females) were fed daily by gavage 0, 5, or 50 mg/kg algal meal in a corn oil suspension for 28 consecutive days (corresponding to daily doses of 0, 350 mg and 3,500 mg algal for 70-kg body weight). After sacrifice, the post-mortem observations, hematology and clinical chemistry failed to detect any sign of toxicity.

An earlier 13-day rat toxicity study demonstrated that the LD50 acute toxicity of *Haematococcus pluvialis* algal meal in rats was greater than 5000 mg/kg.³ In this study, three separate groups of 10 rats (5 males and 5 females per group) were fed 5,000 mg/kg algal meal suspended in a 0.5% methylcellulose solution. Mortality, body weights, necropsy examination and pharmacotoxic signs were evaluated on each group. The study found no remarkable differences in body weights or visible abnormalities. The post-mortem examination after sacrificing the animals at the end of the study revealed no abnormalities.

Another acute toxicity trial was reported with male and female mice.⁴ In this study, *Haematococcus pluvialis* algal meal was suspended in distilled water for gavage to give a 30% solution (w/v). The solution was given in a single dose, at dosages ranging from 10,417 to 18,000 mg/kg. No mortalities occurred and no abnormalities were observed in the post-mortem examination. When converted to a 70-kg body weight, these doses are equivalent to single doses ranging from 729 g to 1,260 g.

1.1.3. Other studies

In salmonids, numerous experiments have shown that *Haematococcus pluvialis* can be incorporated in the diet at dosages ranging from 0.1% to 6% without any negative effect on growth or survival.^{5,6,7,8} A recent report showed no indication of disease, toxicity or neoplasia in fish fed *Haematococcus pluvialis* as a dietary source of astaxanthin.⁴ The fish were reported in excellent nutritional status with abundant body fat. Studies have also

indicated that feeding *Haematococcus pluvialis* can enhance growth and/or survival in trout and shrimp.⁸⁻¹⁰

1.2. Astaxanthin.

Astaxanthin naturally appears in the human diet when seafood such as salmon, red fishes, shrimp, krill or lobster are eaten.

1.2.1. Human studies

The recent clinical safety study, mentioned above, proved the safety of astaxanthin from Aquasearch's *Haematococcus pluvialis* algal meal.¹ In that study, 33 human volunteers (15 males and 18 females, age 28 to 62) ingested on a daily basis, for 29 consecutive days, either 3.85 mg or 19.25 mg algal astaxanthin. As mentioned earlier, extensive blood and urine analyses were conducted throughout the study (Table 1), and the physician conducted a detailed medical examination. Based on the results of these urine and blood analyses and the observations of the physician, no sign of toxicity from astaxanthin was detected even at the higher dose.

In a study with healthy human patients, who ingested up to 14.4 mg/day astaxanthin for two weeks, no ill effect was reported.¹¹ On the contrary, a positive antioxidant effect of astaxanthin on serum Low Density Lipoprotein (LDL) was observed. In that study, thirteen healthy patients were selected, subdivided into 3 groups, and given three levels of astaxanthin daily, for two weeks, as follows: 5 patients fed 3.6 mg/day, 5 patients fed 7.2 mg/day, and 3 patients fed 14.4 mg/day. The astaxanthin was administered sublingually in the form of a softgel capsule. Blood samples were taken and the LDL fraction was collected and exposed to an oxidizing agent. The study demonstrated that increasing doses of astaxanthin significantly and increasingly slowed down the oxidation of the LDL fraction.

1.2.2. Rat toxicity studies

In the recent study with Aquasearch's *Haematococcus pluvialis* algal meal, described above, rats ingested daily up to 1.15 mg astaxanthin per kg body weight (equivalent to 80.5 mg for 70-kg body weight per day), for 28 days, without showing any sub-acute toxicity sign.

Other animal studies on the effects of astaxanthin have shown that even higher doses could be fed to rats for prolonged periods. Some of these studies have demonstrated beneficial

results. In one study, feeding rats 500 ppm astaxanthin for 34 consecutive weeks resulted in reduced cancer occurrence in the intestinal and oral mucosa and improved the condition of the oral cavity.^{12,13}

1.2.3. Safety of astaxanthin in food salmon – safe daily dose of astaxanthin

For years, astaxanthin has been added to aquaculture diets at levels of up to 200 mg/kg, without any toxic effect on target animals. Additionally, numerous studies have demonstrated improved growth, survival and immune response in fish and shrimp.^{8-10,14-23} Astaxanthin is regularly added at 50 ppm or higher to commercial diets fed to food fish for prolonged periods, i. e., for up to 2 years in the case of farmed salmon.

According to the Code of Federal Regulations, astaxanthin is Generally Recognized As Safe ("GRAS") when used as a color additive in salmon foods, with a maximum inclusion of 80 mg/kg feed.²⁴ Numerous studies have shown that such an inclusion level results in accumulation of astaxanthin in the flesh of Atlantic salmon at levels between 4 and 10 mg/kg, and at even higher levels in other species (Table 2).

These levels in Atlantic salmon are comparable to or slightly higher than levels observed in their wild counterparts, but lower than levels found in other wild salmon species found on the Pacific coast of the United States, where values as high as 58 ppm in Sockeye salmon were reported by a recent FDA study.²⁵ (Average of astaxanthin measurements in this study were 13.8 ppm in Coho salmon and 40.4 ppm in Sockeye salmon).

It was noted that the main astaxanthin stereo isomer identified by the FDA researchers in the 5 species of wild Pacific salmon they studied, was the 3S,3'S stereo isomer, identical to that found in *Haematococcus pluvialis*.^{8,25}

Salmon, a fish rich in omega-3 fatty acids, is considered a healthy food, and, like other sources of these poly-unsaturated fatty acids, is highly recommended by nutritionists.²⁶⁻²⁹ According to an epidemiological study on Alaska's native and non-native residents, the lowest rate of ischaemic heart disease mortality, less than one-third that of US Caucasians, occurred in Alaskan Eskimos who lived in an area with documented patterns of high salmon consumption by individuals with high blood concentrations of omega-3 fatty acids.²⁸ Based on the salmon flesh astaxanthin values mentioned above, a daily consumption of a 200-g portion of wild Sockeye salmon with 40 ppm astaxanthin in the flesh would lead to a daily ingestion of 8 mg astaxanthin per day. From a different point of view, the intake of a 5 mg supplement of astaxanthin corresponds to eating 500 g per day

of farmed rainbow trout or Atlantic salmon, 125 g of wild Sockeye salmon, or less than 100 g of krill.

Based on these published data, as well as the animal toxicity data publicly available, it may be inferred that the ingestion of 5 mg astaxanthin per day by an adult human is reasonably safe. This was further substantiated by Aquasearch's 29-day human safety study, which investigated the safety of 3.8 mg astaxanthin/day and 19 mg/day astaxanthin from *Haematococcus pluvialis* algal meal, i. e., almost four-fold higher than the assumed safe daily dose of 5 mg.¹

The results of the extensive blood and urine analyses and complete physical examinations before, during, and at the end of the trial period, raised no apparent safety concern. The data were reviewed by two independent physicians, a clinical pathologist and a professional pharmacotoxicologist, all of who concurred that both doses were safe.

2. Non-mutagenicity of *Haematococcus*

A recent study³⁰ reported no mutagenic effect of *Haematococcus pluvialis* algae, using a mutagenicity test with *Salmonella typhimurium* strains TA100, TA1535, TA98, TA1537, TA1538, and E.coli WP2 uvr A.

In this experiment, *Haematococcus pluvialis* algal meal was formulated in a 50mg/mL solution of dimethyl sulfoxide. The formulation was spread onto petri dishes in the presence of the microbial cultures with positive controls. The positive controls (mutagenic agents): 2-(2-furyl)-3-5(5-nitro-2-furyl)acrylamide, 1-ethyl-2-nitro-3-nitrosoguanidine, 9-aminoacridine, 2-aminoanthracene, and 2-nitrofluorene, showed a remarkable increase in the number of reverent colonies in every case, compared to the solvent control.

3. Carcinogenicity

Haematococcus pluvialis is not known to have any carcinogenic effect, or contain significant levels of recognized carcinogens. On the contrary, *Haematococcus pluvialis* contains a high level of astaxanthin which has widely demonstrated anticarcinogenic effects.³¹⁻³⁵

4. Heavy metals

Haematococcus pluvialis algae produced and processed by Aquasearch for human food consumption meet the Federal Food and drug Administration's list of maximum tolerances:

- Heavy metals (as lead): < 10.0 ppm
- Mercury < 1.0 ppm
- Cadmium < 0.5 ppm
- Arsenic < 2.0 ppm
- Lead < 5.0 ppm

This has been confirmed by analyses of various batches (Lot HP980051³⁶ and Lot 990610Mix³⁷, a blend resulting from combining five batches: Lots 990513A, 990518B, 990520A, 990524A, 990526A, and therefore, highly representative of the quality of *Haematococcus pluvialis* algal meal produced with Aquasearch's technology).

5. Bacteriology

Manufacturing process follows FDA GMP recommendations for food supplements to avoid spoilage and contamination of *Haematococcus pluvialis* algal meal by harmful micro-organisms or other types of contaminants.

During the processing, the algal biomass is mechanically cell-broken to ensure a thorough rupture of cell walls, undergoes a pasteurization process, and is dried to a moisture content less than 5%. The pasteurization treatment ensures that the following bacteriological specifications in the final product are achieved, as confirmed by analyses by an independent laboratory³⁷:

- Total aerobic plate count <1,000 CFU
- Total coliforms <10/g
- *E. coli* <10/g
- *Salmonella* absence in 25 g

6. Other natural toxic compounds and toxicity risks

Aquasearch is not aware of any significant or detectable levels of known carcinogenic or toxic compounds in *Haematococcus pluvialis* algae that could have a negative effect on human health.

Analyses on the algae meal have demonstrated absence of mycotoxins, and especially of aflatoxins.^{36,37}

Haematococcus pluvialis may contain small amounts of canthaxanthin, a carotenoid

pigment closely related to astaxanthin. Analyses have shown that canthaxanthin concentrations in *Haematococcus pluvialis* algal meal produced with Aquasearch proprietary technology are less than 2% of total astaxanthin concentration. Aquasearch's proprietary technology maximizes astaxanthin biosynthesis by *Haematococcus pluvialis* and in so doing also minimizes the relative proportion of other carotenoids (including canthaxanthin).

At the levels of canthaxanthin encountered in Aquasearch's algal meal, a daily dose of 5 mg algal astaxanthin as a supplement would entail also ingesting 0.1 mg canthaxanthin per day. Although canthaxanthin has been demonstrated to have positive metabolic effects such as an anticancer activity,³⁸ there has been reports that, at high doses for prolonged periods, it can have negative effects. One case of aplastic anemia associated with canthaxanthin ingested for tanning purposes, was reported a few years ago³⁹. Others have reported the appearance of crystalline formations in the retina of some individuals who ingested up to 66 g cantaxanthin over 24 months (corresponding to an average daily ingestion of 90 mg cantaxanthin per day) for tanning purposes⁴⁰. However, later it was demonstrated that these canthaxanthin deposits in the retina could be reversed³⁹. In any case, the levels of canthaxanthin that would be ingested through a 5 mg astaxanthin dietary supplement formulated with Aquasearch's algal meal are nearly 1000-fold lower than the doses which were observed to cause canthaxanthin maculopathy. Therefore, they should represent no safety risk.

The rat toxicity and human studies which were conducted with Aquasearch's algal meal confirmed this. It should also be noted that FDA has approved canthaxanthin as a color additive in fish foods (up to 80 mg/kg feed, which can result in canthaxanthin deposition levels of 4 to 12 mg/kg fillet) and broiler diets, as well as in foods and drugs.⁴¹ In foods, the limit authorized by FDA is 30 mg canthaxanthin per pound of solid food. The ingestion of 0.1 mg cantaxanthin in a dietary supplement containing 5 mg astaxanthin, is therefore well below the levels that would be encountered in foods that are considered safe by FDA.

7. Product specifications

A detailed description of the manufacturing process and of the specifications of *Haematococcus pluvialis* for use in dietary supplements are reviewed in a separate technical report.⁴²

8. Metabolic effects of astaxanthin

Astaxanthin is a powerful natural antioxidant. There is a growing amount of scientific

evidence not only on the safety of astaxanthin for human consumption, but on the positive metabolic effects that it may have. These findings have been reviewed in detail in Aquasearch Technical Reports TR.3002.001⁴³ and TR.3003.001⁴⁴.

9. Dietary studies - safe daily dose of algal astaxanthin

Astaxanthin appears to be absorbed in the blood in the same way as other carotenoids. Carotenoids are absorbed by passive diffusion through the intestinal mucosa after being emulsified and solubilized in lipid micelles which are incorporated into chylomicrons when exiting the intestinal mucosal cells.⁴⁵ They are transported in the blood after being transferred from the chylomicrons to lipoproteins.

In a recent human study, a single dose of 100 mg dietary astaxanthin was not found to have any negative effect and demonstrated that astaxanthin has a similar absorption pattern to other carotenoids.⁴⁶ Astaxanthin was measured in the blood plasma of 3 middle-aged male subjects after ingestion of a single dose of 100 mg astaxanthin. Astaxanthin was readily absorbed and transported by various lipoproteins: chylomicrons/Very Low Density Lipoproteins, High Density Lipoproteins and Low Density Lipoproteins.

Plasma levels of astaxanthin peaked at 1.2 mg/L (= 2 µmol/L) after 6 hours and progressively declined over the next 66 hours to a 0.2 mg/L level. These levels and duration are comparable to levels reported in the literature for other carotenoids.⁴⁷⁻⁴⁹ Astaxanthin appears to be absorbed at a similar rate than beta-carotene which peaks in the serum after 6 to 9 h.⁴⁹ In mice, astaxanthin also appeared to be absorbed quite effectively, when compared to beta-carotene or lutein.⁴⁹

The official recommended dietary intake for vitamin A is 1,000 retinol equivalents, for men, and 800 for women.⁵¹ This corresponds to 6 µg (*micrograms*) beta-carotene or 12 µg of other pro-vitamin A carotenoids.⁵¹ On the other hand, practical levels of carotenoid intake are significantly higher. Epidemiological studies in North Europe have found daily ingestion of carotenoids ranging from 2.9 to 7.6 mg/ (*milligrams*) per day,⁵²⁻⁵⁴ while in the US, the level of carotenoids supplied by the "normal" diet is estimated to be 1.5 mg beta-carotene per day.⁵¹

The Alliance for Aging Research, a US Citizen Advocacy organization for research to improve the health and independence of older people, has recommended 10 to 30 mg beta-carotene per day for optimal health, and doses of 20 to 180 mg beta-carotene for

many years have been used to treat erythropoietic protoporphyria, with no evidence of toxicity and without development of abnormally-elevated blood vitamin A levels.⁵¹ In addition it should be noted that astaxanthin, unlike other carotenoids such as beta-carotene, has no provitamin A activity;^{55,56} therefore it represents a lower risk of hyper-vitaminosis A.

It may be argued that because astaxanthin is closely related to canthaxanthin it could also have similar toxic effects as those described above. However, the available data indicate that astaxanthin consumption at no greater than the recommended dose of 5 mg per day poses no safety risk:

- The proposed daily intake of astaxanthin (5 mg) is much lower than the levels of canthaxanthin which were found to have toxic effects (up to 90 mg average daily intake for 24 months).
- The human safety study conducted with Aquasearch's algal astaxanthin found no changes in vision or eye condition in the patients. Another good indicator, skin coloration, did not change throughout the Aquasearch safety study.
- The post-mortem examination of the animals in Aquasearch's rat toxicity study also failed to find any adverse effect of astaxanthin supplementation at the doses tested.
- Researchers at the University of Illinois also reported that, in an animal model (rats), astaxanthin, unlike canthaxanthin, did not form crystalline depositions in the eye.⁵⁷ Furthermore, they demonstrated that astaxanthin can have a beneficial role in the protection of the eyes from UV-light damage.

In conclusion, based on published studies (reviewed above), on natural levels of astaxanthin found in seafood, and on the results of the studies conducted by Aquasearch, it appears that the consumption by a healthy adult human of a daily dose of 5 mg astaxanthin, in the form of a supplement formulated with 250 mg (or less) *Haematococcus pluvialis* algal meal produced with Aquasearch's proprietary technology, represents no safety risk. This suggested dose is approximately four times lower than the high dose which was demonstrated to be safe by Aquasearch's safety study.

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Table 1: List of analyses in human safety study conducted on Aquasearch's *Haematococcus pluvialis* algal meal.¹

Blood chemistry analyses

Serum glutamate pyruvate transaminase (SGPT)
Lactate dehydrogenase (LDH)
Glucose
Total protein
Total bilirubin
Blood urea nitrogen (BUN)
Creatinine
Total cholesterol
High-density lipoprotein (HDL) cholesterol
Triglycerides
Low-density lipoprotein (LDL) cholesterol (calculated)
Albumin
Globulin

Complete blood count (CBC)

White blood count (WBC)
Red blood count (RBC)
Hemoglobine (HGB)
Hematocrit (HCT)
Mean corpuscular volume (MCV)
Mean corpuscular hemoglobin (MCH)
Mean corpuscular hemoglobin concentration (MCHC)
Red cell distribution width (RDW)
Platelet count
Neutrophil (segs)
Lymphocytes
Monocytes
Eosinophils
Bsophils
Red blood cell morphology
Coagulation test (activated partial thromboplastin time, PTT)

Urinalysis tests

Color	pH
Appearance	Protein
Specific gravity	Glucose
Leukocyte esterase	Ketones
Nitrite	Urobilinogen
Blood	Bilirubin

Table 2. Levels of of astaxanthin in selected types of seafoods⁸

Seafood type	Astaxanthin		
	Content (mg/kg)	Free/esterified	Main isomer
Sockeye salmon	26-37	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Coho salmon	9-21	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Chum salmon	3-8	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Chinook salmon	8-9	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Pink salmon	4-6	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Atlantic salmon	3-11	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
Rainbow trout	1-3	Free,esterified**	3 <i>S</i> ,3' <i>S</i>
salmon eggs	0-14	Esterified***	N.A.
Red seabream	2-14	Esterified***	N.A.
Red seabream eggs	3-8	N.A.	N.A.
<i>Peneaus monodon</i>	10-150	Esterified,free**	3 <i>S</i> ,3' <i>S</i>
Lobster		Esterified,free**	N.A.*
Krill	46-130	Esterified***	3 <i>R</i> ,3' <i>R</i>
Krill oil	727	Esterified***	3 <i>R</i> ,3' <i>R</i>
Crayfish meal	137	Esterified***	N.A.*
Artic shrimp	1160	Esterified***	3 <i>S</i> ,3' <i>S</i>
<i>Haematococcus pluvialis</i>	10,000-30,000	Esterified***	3 <i>S</i> ,3' <i>S</i>

- * Most crustaceans studied appear to have mostly the 3*S*,3'*S* form, unlike Krill.
- ** depending on tissues, free or esterified astaxanthin may be found
- *** also contain a small proportion of free astaxanthin

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[Return to Safety Information](#)
[Return to Clinical Safety Study](#)

KOREA FOOD & DRUG ADMINISTRATION

SUBJECT : REGARDING KRILL PRODUCT

QUESTION FROM SAM OH

: THERE IS EPA AND/OR DHA FOOD IN HEALTH FOOD CATERGORIES AND, ITS DEFINITION IS 'A THINGS FROM EDIABLE FISHES, AQUATIC ANIMALS AND ALGAE;

WE HAVE A KRILL OIL (OMEGA 3 FATTY ACIDS (EPA/DHA) CONTENT 40% UP) AND, WE WOULD LIKE TO KNOW WHETHER THIS KRILL OIL IS EPA AND/ OR DHA FOOD. PLEASE INVESTIGATE AND LET US KNOW YOUR RESULT.

ANSWER FROM FOOD EVALUATION DEPARTMENT

: KRILL PRODUCT IS ACCEPTABLE AS A RAW MATERIAL FOR HEALTH FOOD BECAUSE IT IS CLASSIFIED INTO EDIABLE MATERIAL AND, KRILL OIL IS ALSO ACCEPTABLE AS EPA/DHA FOOD YOU CAN MEET THE KOREA FOOD CODE.

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제 목 크릴새우에 대한 질의회신

1. 사이버민원 9125호(2002. 2. 2)와 관련입니다.

2. 현재 크릴새우는 식용가능한 식품원료로 분류되어 있으므로 건강보조식품의 원료로 사용가능하다고 판단되며, 질의하신 제품이 크릴새우에서 채취한 EPA/DHA 등의 지방산을 함유한 유지를 식용에 적합하도록 정제한 것 또는 이를 주원료로 하여 성취가 용이하도록 액상, 페이스트상, 분말, 과립, 정제 또는 캡슐로 가공한 것이고, 식품공전상 기준·규격에 적합하다면 EPA/DHA 함유식품으로 분류될 수 있습니다. 끝.

식품의약품안전청

